

CLAIMS

What is claimed is:

- 5 1. A spin-current switched magnetic memory element, comprising:
a plurality of magnetic layers, at least one of said plurality of magnetic layers having a
perpendicular magnetic anisotropy component and comprising a current-switchable magnetic
moment; and
at least one barrier layer formed adjacent to said plurality of magnetic layers.
- 10 2. The spin-current switched magnetic memory element according to claim 1, wherein said
plurality of magnetic layers comprises at least one composite layer.
3. The spin-current switched magnetic memory element according to claim 2, wherein said
15 at least one composite layer comprises a platinum layer and a cobalt layer.
4. The spin-current switched magnetic memory element according to claim 2, wherein said
at least one composite layer comprises a gold layer and a cobalt layer.
- 20 5. The spin-current switched magnetic memory element according to claim 2, wherein said
at least one composite layer comprises a nickel layer and a copper layer.
6. The spin-current switched magnetic memory element according to claim 2, wherein said

perpendicular magnetic anisotropy component is formed at an interface between a magnetic layer and non-magnetic layer of said at least one composite layer.

7. The spin-current switched magnetic memory element according to claim 2, wherein said
5 perpendicular magnetic anisotropy component comprises a bulk perpendicular magnetic anisotropy component which is formed in a magnetic layer of the said at least one composite layer.

9. The spin-current switched magnetic memory element according to claim 1, further
10 comprising:

first and second leads; and

a pillar formed between said first and second leads, said pillar including said at least one barrier layer and at least one magnetic layer of said plurality of magnetic layers.

10. The spin-current switched magnetic memory element according to claim 9, wherein said
15 at least one magnetic layer included in said pillar comprises said current-switchable magnetic moment.

11. The spin-current switched magnetic memory element according to claim 10, wherein said
20 magnetic moment of said at least one magnetic layer included in said pillar is switchable by an electrical current having a density of no more than about 10^6 A/cm².

12. The spin-current switched magnetic memory element according to claim 9, wherein said

barrier layer preserves spin information for an electric current injected into said pillar and provides a resistance to said current.

13. The spin-current switched magnetic memory element according to claim 9, wherein at least one of said first and second leads includes a magnetic layer of said plurality of magnetic layers.

14. The spin-current switched magnetic memory element according to claim 1, wherein said plurality of magnetic layers comprises an upper magnetic layer and a lower magnetic layer, said at least one barrier layer being formed between said upper and lower magnetic layers.

15. The spin-current switched magnetic memory element according to claim 14, wherein said upper magnetic layer comprises one of a platinum layer formed on a cobalt layer, and a gold layer formed on a cobalt layer.

16. The spin-current switched magnetic memory element according to claim 14, wherein said lower magnetic layer comprises one of a cobalt layer formed on a platinum layer, a cobalt layer formed on a gold layer, and a nickel layer formed on a copper layer.

17. The spin-current switched magnetic memory element according to claim 1, wherein said perpendicular magnetic anisotropy has a magnitude sufficient to at least substantially offset an easy-plane demagnetization effect, such that a magnetic moment of one of said upper and lower magnetic layers is either resting out of the film plane or can be rotated out of the film plane under spin current excitation.

18. The spin-current switched magnetic memory element according to claim 1, wherein said at least one barrier layer comprises a plurality of barrier layers which are alternately formed with said plurality of magnetic layers.

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19. The spin-current switched magnetic memory element according to claim 9, wherein said pillar comprises a lithographed pillar having a diameter of less than about 100 nm, and having an oblong-shaped cross-section.

10 20. The spin-current switched magnetic memory element according to claim 1, wherein said at least one barrier layer comprises a tunneling barrier layer.

21. The spin-current switched magnetic memory element according to claim 1, wherein said at least one barrier layer comprises at least one of an aluminum oxide layer, a magnesium oxide
15 layer, a doped semiconductor layer, a non-magnetic metal layer and a SrTiO₃ layer.

22. The spin-current switched magnetic memory element according to claim 14, wherein said lower magnetic layer comprises a first nickel layer formed on a first copper layer, and said upper magnetic layer comprises a second copper layer formed on a second nickel layer.

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23. The spin-current switched magnetic memory element according to claim 22, wherein said second nickel layer has a thickness which is different than a thickness of said first nickel layer, and has a magnetic moment which is perpendicular to a film plane, and wherein one of said first and second nickel layers represents an information state and has a magnetic moment which is

rotatable under an influence of a write current, and the other provides a reference magnetic direction which is not rotatable under said influence of said write current.

24. The spin-current switched magnetic memory element according to claim 14, wherein said
5 lower magnetic layer comprises a first cobalt layer formed on a first platinum layer, and said upper magnetic layer comprises a second platinum layer formed on a second cobalt layer.

25. The spin-current switched magnetic memory element according to claim 14, wherein said
10 pillar has an electrical resistance which depends on a magnetization direction of said lower magnetic layer with respect to a magnetization direction of said upper layer.

26. The spin-current switched magnetic memory element according to claim 14, wherein said
15 pillar comprises a magnetic tunneling junction across said barrier layer between said upper and lower magnetic layers.

27. A spin-current switched magnetic memory element, comprising:
first and second leads;
a pillar formed between said first and second leads,
a plurality of magnetic layers, at least one of said plurality of magnetic layers having a
20 perpendicular magnetic anisotropy component and comprising a current-switchable magnetic moment; and
at least one barrier layer formed in said pillar adjacent to said plurality of magnetic layers.

28. A magnetic random access memory (MRAM) array comprising a plurality of magnetic
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spin-current switched magnetic memory elements according to claim 27.

29. A method of fabricating a spin-current switched magnetic memory element, said method comprising:

5 providing a wafer having a bottom electrode;

forming a plurality of layers, such that interfaces between said plurality of layers are formed in situ, said plurality of layers comprising:

a plurality of magnetic layers, at least one of said plurality of magnetic layers having a perpendicular magnetic anisotropy component and comprising a current-switchable

10 magnetic moment; and

at least one barrier layer formed adjacent to said plurality of magnetic layers;

lithographically defining a pillar structure from said plurality of layers; and

forming a top electrode on said pillar structure.

15 30. The method according to claim 29, wherein said at least one barrier layer comprises a plurality of barrier layers which are alternately formed with said plurality of magnetic layers.